Policy, Planning, and Research

WORKING PAPERS

Agricultural Policies

Agriculture and Rural Development Department
The World Bank
November 1989
WPS 303

Is Undernutrition Responsive to Changes in Incomes?

Martin Ravallion

An approach is offered for simulating the effects of income and price changes on various measures of undernutrition, using caloric intake functions. It is argued that recent econometric estimates of the income elasticity of caloric intake may considerably understate the effect of income changes on measures of aggregate undernutrition. Empirical results are for Indonesia.

Is aggregate undernutrition responsive to changes in individual incomes?

One problem in answering this question is defining undernutrition. The extent of undernutrition depends not only on nutrient intakes but on other factors, including nutrient requirements — which may differ widely amongst people.

In developing countries, we are more concerned about changes in caloric intake for people who we deem to be "undernourished" than for those who are not. And among those who are poorly nourished, we should be more concerned about those who are a long way from adequate intake than about those who are close to it.

Ravallion offers an approach to measuring the effects of shifts in budget constraints or other household parameters on undernutrition — an approach that can address those issues.

Using household data on calorie consumption, income, prices, and other household characteristics for the province of East Java in Indonesia, Ravallion illustrates how to:

- Estimate caloric intake functions for that data.

- Use those functions to simulate the effects of income changes on various measures of caloric undernutrition. Those measures include the popular headcount index and two alternative measures more responsive to the depth of undernutrition, and to individual variations in its severity.

He proposes a method for accounting for interhousehold differences in nutritional needs, based on estimate calorie intake functions. Thus the caloric norm need only be predetermined for a specific reference person or household.

Ravallion finds that the income elasticity of measured undernutrition is considerably higher than the income elasticity of individual caloric intakes. The reason is that the density of people tends to be high in a neighborhood of requirement norms, and intake responses tend to be highest amongst those who are least well nourished. Recent arguments that intakes are unresponsive to income changes should thus be interpreted with caution.

This paper is a product of the Agricultural Policies Division, Agriculture and Rural Development Department. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Cicely Spooner, room N8-039, extension 30464 (45 pages with tables).

Is Undernutrition Responsive to Changes in Incomes?*

by
Martin Ravallion

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* For their helpful comments on this paper I am grateful to Michael Lipton, Shlomo Reutlinger, seminar participants at the University of Pennsylvania, and the journal's referees. The paper draws on empirical work undertaken at the Australian National University during 1988.

Reference: Economic Development and Cultural Change, April 1990.

1. Introduction

The effects on undernutrition of economic growth or contraction, and of changes in the distribution of income, are of great concern. A number of recent empirical studies have suggested that nutrition levels in poor countries may be relatively unresponsive to income changes, with elasticities a good deal less than the income elasticities of demand for food-staples.[1] This can be explained as an effect of consumer substitution between the nutritional and other ("taste") attributes within food-staple aggregates.[2] Thus, for example, the increase in an expenditure weighted quantity index of rice consumption due to an income gain may hide the consumer's substitution toward a better tasting (and hence more expensive) grade of rice, with little or no gain in nutrient value.

At first sight this argument may seem difficult to reconcile with recent claims that measures of nutritional deprivation are quite responsive to income changes, such as those associated with recent macroeconomic and structural adjustments in many developing countries.[3] The argument may also appear to sit rather uneasily with the "entitlements approach" to the study of famines;[4] surely if caloric intakes of the poor are income unresponsive one would not expect entitlement failures to result in mass starvation.

Such concerns have led some observers to doubt the recent empirical evidence that income elasticities of nutrient intake are low in these settings. The econometric results have seemed counter-intuitive, possibly reflecting data inadequacies.[5] Others have broadly accepted the empirical results and have concluded that the link between poverty and undernutrition may be a good deal weaker than we have thought; for example, economic growth benefiting the poor may have little impact on the number of undernourished persons.

However, these conclusions cannot be supported _solely_ by the observation that the income elasticity of nutrient intake is low. The seemingly conflicting observations mentioned above can be readily reconciled if interpersonal nutrient distributions have sufficiently high density in a neighborhood of the minimum requirement levels relevant to assessing nutritional deprivation. For it can be readily shown that the marginal effect of a change in the incomes of undernourished households on a headcount index of undernutrition is determined by the product of the income slope of nutrient intake _and_ the slope of the cumulative distribution function of intake, evaluated at the nutrient norm.[6] If the latter slope is high then small contractions in nutrient intake consequent to a fall in income may lead to large shifts in a headcount assessment of nutritional inadequacy. Even if income elasticities of nutrient demand are low, as long as they remain positive, and interpersonal nutrient distributions are dense at the norm, one may still be rightly concerned about the effects of income contractions on the extent of malnutrition and even mortality. And, by the same reasoning, one may also remain optimistic about the prospects for eliminating nutritional deprivation by raising incomes of the poor.

These arguments have less force when one considers alternative measures of undernutrition that do not share the headcount's sensitivity to changes at the cut-off point. For example, a measure such as the mean caloric deficit will clearly be less responsive to shifts in the density of caloric intake near the norm than is the headcount index. However, such a measure is implicitly "monotonic" in that it gives higher weight to more poorly nourished persons. And here it may also be argued that income responses of intake will tend to be higher (ceteris paribus) among such persons. The combined effect of these two factors - the monotonicity of undernutrition in intake and the concavity of intake in income - may well be to yield considerably higher income responses of measured undernutrition than suggested by the income elasticity of intake at the mean.[7]

The essential point here is that "nutrient intake" and "undernutrition" are really quite distinct concepts. The extent of undernutrition will depend not only on nutrient intakes, but also on other factors, including, of course, nutrient requirements. Nor is the relationship linear; a seemingly small difference in intake between two otherwise identical persons can be associated with a large difference in the severity of their undernutrition.

Against these arguments, it may be contended that one can still usefully study the nutritional consequences of income changes without addressing the (potentially difficult) issue of how undernutrition is to be measured. One may prefer to stop at estimating the effects of income changes on intakes, as past researchers have typically done.[8] But casual reflection suggests that our underlying concerns about such effects, including their policy implications, rest heavily on concepts of "undernutrition". The resolution of those concerns will then rest both on the issue of how nutrient distributions respond to income changes (or other changes in household or individual parameters), and that of how such responses are to be aggregated, involving perforce the issue of how interpersonal comparisons of nutrient attainment are to be made. For example, it is clear that in developing countries we are far more concerned about changes in caloric intake for people who we deem to be "undernourished" than for those who are not. And amongst those persons who are poorly nourished, one can rightly be more concerned about those who are a long way from an adequate intake than those who are quite close to it.

This article offers an approach to the measurement of the effects of shifts in budget constraints or other household parameters on undernutrition - an approach that is capable of addressing these issues. The approach is illustrated by using a large household level data set on calorie consumptions, incomes, prices and other household characteristics for the province of East Java in Indonesia. The twin objectives of the empirical work are to i) estimate calorie intake functions for these data and, ii) use those functions to simulate the effects of income changes on various measures of caloric undernutrition. These measures include the popular headcount index, and two alternative measures more responsive to the depth of undernutrition, and to interpersonal variations in its severity. A consistent method of accounting for inter-household differences in nutritional needs when assessing attainment is proposed, based on estimated calorie intake functions. Thus the caloric norm need only be pre-determined for a specific reference person or household.

East Java was selected for a number of reasons. The choice had been stimulated in part by my participation in a research project at the Australian National University (ANU) on the development of East Java, so that a body of complementary knowledge could be easily accessed.[9] A sufficiently detailed and large household level data set for the Province was also readily available at ANU, as a subset of the 1981 National Socioeconomic Survey (SUSENAS) done by the Central Bureau of Statistics, Indonesia. Aside from these pragmatic reasons, East Java is of intrinsic interest as a case-study for examining incomes effects on undernutrition.

Within the Indonesian archipelago, the prevalance of nutritional deficiency in East Java appears to be high; for example Chernichovsky and Meesook estimate that in 1978, 72 percent of the population of East Java did not attain an adult energy intake of about 2100 calories per day.[10] The region is also notable for its economic dualism and geographic diversity; rapidly developing industrial areas (notably in the Surabaya region) are found in relatively close proximity to agricultural areas of rather low productivity (such as the island of Madura, and the limestone hill areas of the South-west).[11] Thus East Java provides an interesting case-study of how undernutrition and its income responsiveness vary between urban and rural sectors of a developing economy. The level of income inequality in East Java (associated with the province's dualism and intra-sectoral diversity) suggests that one may have a better chance of picking up the aformentioned non-linearity (concavity) in income effects on nutrient demand than seems to have been the case with some past data sets.[12]

The following section outlines an approach to modeling nutrient demands at the household level, and discusses how this can be used in controlling for household heterogeneity in nutritional "needs" and "tastes". Relevant issues concerning nutrient norms are also discussed. Section 3 applies the approach to a cross-sectional data set of 7,200 households in East Java for 1981. The results are used in Section 4 to simulate the effects of budget shifts on various measures of the extent of caloric undernutrition. Section 5 offers some conclusions.

2. An Approach to Measurement Using Household Level Data

When attempting empirically to identify income and price effects on nutrient demands and undernutrition it is clearly important to control effectively for non-budgetary personal or household characteristics. For example, two prominent "stylized facts" about nutrition in South and Southeast Asia are that market prices of foodgrains tend to be higher in urban than rural areas (reflecting transport costs or other impediments to spatial market integration),[13] and that calorie intakes tend to be lower. The first stylized fact may be offered as one possible explanation for the second. But there are other factors to consider. For example, non-market foodgrain consumption opportunities may be more important in rural areas. Energy needs may also tend to be higher in rural areas, since agricultural labour tends to be more physically demanding than many "urban" activities. And it might also be contended that tastes tend to be different between the traditional (mainly rural) and modern (urban) sectors.

In assessing undernutrition it is also crucial to define and control for nutritional "needs" in a meaningful way. Nutritionsts have estimated requirements levels for a few stylized types of individuals of given personal characteristics and activities. Most sampled households will be different to these references. When using household data it is common to normalize the total calorie intakes of households by household size, although the relevance of demographic composition is also widely recognized. This is then compared to an average requirement. In principle, one would also like to make allowance for a variety of other characteristics relevant to energy needs, such as the type of work performed and personal constitution. The omission of activity levels when modeling intakes may also lead to biased estimates of income effects, though the direction of any bias is not obvious. One may also wish to control for random intra-individual fluctuations in intake.

Non-budgetary variables are thus of relevance to measuring the effect of budget shifts on undernutrition in two ways: there exists a potential for omitted variable bias in measuring the income and price responsiveness of calorie intake, and there is a need to control for certain household and personal characteristics in assessing undernutrition.

An Econometric Method for Measuring Undernutrition

A suitably general econometric model of calorie demand can be used to deal with the above issues. The same set of non-budgetary variables included to avoid omitted variable bias in the coefficients on the budgetary variables can be used to control for household heterogeneity in relevant non-budgetary characteristics. In doing so it is assumed that all variables relevant to defining requirements also affect intakes. In particular, I shall use an econometric model of calorie consumption to estimate the consumption of each household, as if it had the fixed non-budgetary characteristics of a reference household rather than its own. This estimated consumption level is then compared to the (pre-determined) caloric requirements of the reference household so as to assess each household's actual caloric attainment. In discussing the method, I shall assume that the unit of observation is the household, though with suitable data the approach can be readily adapted to individual observations. Of course, with only household level data one cannot say anything about intra-household distribution. This may be an important limitation of such data.

To make the approach more precise, suppose that the total calorie (or other nutrient) consumption (k_i) of the ith household is a function of: i) household budget constraints, which depend solely on incomes (y_i), and prices (p_i), and ii) various indicators of the energy needs and tastes of household members (the vector x_i). Thus:

$$k_i = k(y_i, p_i, x_i) \quad (i = 1,\ldots,N) \tag{1}$$

The vector x is taken to include all variables which may be deemed relevant in controlling for household heterogeneity. This may include, for example, household size, demographic composition, the body weights of household members or seemingly random fluctuations in intake. Let the "control variables" used in defining the reference household be x_{1i}, so that $x_i = (x_{1i}, x_{2i})$. The reference calorie consumption, k_i^r, of the ith household if it had the reference characteristics x_1^r fixed across all households is given by

$$k_i^r = k(y_i, p_i, x_1^r, x_{2i}) \tag{2}$$

By construction, this will vary solely according to the budgetary circumstances (parametized by p_i and y_i) and any other variables not deemed to be relevant in defining nutritional requirements (x_{2i}). The nutrient requirement of the reference household is denoted z.

Empirical assessments of caloric undernutrition in this paper will be based solely on comparisons of reference calorie consumption, as estimated from an econometric model based on explicit functional forms for equation (1). A household is deemed to be undernourished if (and only if) $k_i^r < z$. The extent of that household's undernutrition is then measured by a function $u(k_i^r, z)$ which is non-increasing in k_i^r and non-decreasing in z and vanishes for all $k_i^r \geq z$. This is then summed over all households to give aggregate undernutrition:

$$U = \Sigma\, u(k_i^r, z) \tag{3}$$

Notice that this formulation implicitly assumes that changes in household characteristics only affect individual (and, hence, aggregate) undernutrition in so far as they affect caloric intakes. This may not be a harmless assumption; healthier individuals, for example, may be deemed less undernourished at given caloric intakes.[14] However, such effects are difficult to quantify, since it is nutrient intake rather than undernutrition that is actually measured.

In the empirical work, I shall assume that the function u is the class of functions proposed by Foster, Greer and Thorbecke for measuring poverty,[15] namely

$$u(k_i^r, z) = \left(\frac{z - k_i^r}{z}\right)^{\alpha} \quad (\alpha \geq 0) \text{ for } k_i^r < z \tag{4}$$
$$= 0 \text{ otherwise}$$

The parameter α is allowed to take three possible values: i) $\alpha = 0$, in which case, when (4) is substituted into (3) one obtains the simple headcount index of undernutrition which has been the most popular measure in the literature;[16] ii) $\alpha = 1$, giving the proportionate calorie gap based on the aggregate calorie deficit of undernourished households; and iii) $\alpha = 2$, when one obtains a distribution-sensitive measure, satisfying Sen's Transfer Axiom.[17]

An appealing feature of the above approach to the measurement of undernutrition is that one need only specify the nutrient requirement level of the reference household. Of course, this task is not straightforward, and I shall discuss some of the issues involved later. But it is clearly far less demanding empirically than an approach that calls for a requirement level for each household, and more satisfying than one which ignores inter-household variability in nutrient needs.

It is, however, of interest to compare this approach with one which is based on comparisons of actual intakes with pre-determined requirements at the household level.[18] An important difference is that requirements for non-reference households are not pre-determined here, but are derived consistently with observed caloric intakes, conditional on the variables which are deemed to be relevant in assessing need. But even without this difference, the two approaches may not agree. Consider, for example, the approach to the measurement of undernutrition recently proposed by Nanak Kakwani.[19] Kakwani's measure is also based on a Foster-Greer-Thorbecke functional form for undernutrition such as (4), with the difference that this is defined on individual intakes and requirements, giving

$$u(k_i, r_i) = \left(\frac{r_i - k_i}{r_i}\right)^{\alpha} \quad (\alpha \geq 0) \text{ for } k_i < r_i \qquad (5)$$

$$= 0 \text{ otherwise}$$

Aggregate undernutrition is then obtained (analogously to (3)) by summing $u(k_i, r_i)$ over all i. It can be readily seen that these two approaches are equivalent if the calorie demand functions given by (1) are linear homogeneous in requirements, thereby taking the form:

$$k_i = g(y_i, p_i, x_{2i})r(x_{1i}) \tag{6}$$

where $r(x_{1i})$ is the requirement of a household with relevant attributes x_{1i} and $z = r(x_1^r)$. Then both measures collapse to $(1-g(y_i, p_i, x_{2i}))^{\alpha})$. However, there is no obvious reason why a homogeneity restriction such as (6) should be imposed on a calorie demand model, and so I have not done so in the empirical work.

As an aside, it may be noted that a number of past empirical studies of calorie demand functions have normalized actual intakes by pre-determined requirement levels, such as Recommended Daily Allowances.[20] This practice can be interpreted as a special case of that proposed here; by assuming that the requirement function r in (6) is known, and that the homogeneity restriction in (6) holds, one can re-specify the calorie intake model with intake normalized by requirement as the dependent variable, and without the control variables x_1 appearing on the right-hand side.

Certain conceptual difficulties arise in defining the control variables x_1. The same issues also arise in attempts to measure household specific requirements. Two basic problems can be identified:

i) Variables describing the size and composition of the household may be considered to be fairly obvious measures of a household's energy needs, as are the age, sex, and body-weights of household members. Nutrition norms are often defined in terms of such variables.[21] However, some other variables are less obvious, and may equally well be viewed as determinants of budget constraints or tastes rather than energy needs. For example, calorie consumption tends to be higher (ceteris paribus) for farming households than others; this may be because farm work tends to be more strenuous (so that energy needs are higher), or because farm households may face a more favourable budget constraint at given incomes and market prices; for example, because of transaction costs, market prices may overstate the opportunity cost of consuming food from the farm-household's own-production.

ii) Variations in nutritional "tastes" pose a similar problem. Should a household be deemed energy poor if it has an inadequate calorie consumption at reference needs while another seemingly identical household with the same budget constraint does not? Some might argue that one should control for such heterogeneity in tastes when assessing undernutrition, so that households with the same needs and budget constraints should, as a matter of principle, be treated identically. Others may argue that variations in both tastes and budgets are relevant to assessing actual nutritional deprivation. The issue is further complicated by the fact that it may not be obvious whether a particular variable is an indicator of "needs" or "tastes". For example, with a better education, the energy requirements of the available jobs will change, but so may tastes, as one becomes better informed about the nutritional values of various foods. Also, the regression residuals in econometric models based on (1) undoubtedly include taste variability, as well as, for example, omitted needs, but these cannot, of course, be distinguished.

These are difficult issues to resolve on a priori grounds and so one should investigate the sensitivity of key conclusions. For example, one may ask whether those conclusions change if one attempts to control for all variation in non-budgetary characteristics when assessing caloric undernutrition.

On Nutrient Norms

The assessment of norms is fraught with conceptual and empirical difficulties.[22] It is widely agreed that nutrient requirements will vary between households according to their size, composition, work activities, and possibly other factors, as discussed above. In the present approach, this is entirely a matter of the attributes one uses in defining the reference household when making interpersonal comparisons of nutrient attainment. The preceeding discussion has pointed to a number of issues that arise in specifying relevant attributes, and has advocated sensitivity tests. A further contentious issue is the location of the caloric norm for the reference household. In view of the uncertainties that arise here, the present study uses a wide range of norms, in an attempt to encompass reasonable alternatives.

However, the existence of a fixed norm for the reference household is assumed. This may be more contentious. For it has been argued that human regulatory mechanisms allow energy expenditures to adapt to changes in nutritional intake (arising from, for example, income changes) such that the very existence of a fixed requirement level for the reference household is unlikely.[23] Rather there exist (it is claimed) multiple intake-expenditure equilibria at which body weight is locally maintained (though not necessarily with the same body weight for each equilibrium). Thus an income gain may alter requirement as well as intake. The present approach will over-state the responsiveness of caloric undernutrition to income changes if the assumption of a fixed (though uncertain) caloric norm for the reference household is not valid and the norm shifts in the same direction as the calorie distribution.[24]

There are a number of points that should, however, be noted. While there is some clinical evidence of short-term adaptation, so far the case for the existence of long-term adaptation seems far less convincing[25] It is also widely agreed that there are biological limits to adaptation; the possibilities of sustained downward adaptation clearly become negligible at low intake-expenditure equilibria.

But even if one accepts that requirements will respond to an income change through adaptation, it is not obvious that the two variables will be positively correlated. The source of the income gain is clearly important.[26] If it arises, for example, from an increase in work effort then an upward revision to energy requirements would be appropriate. But the income gain may equally well be associated with less physically strenuous jobs, with lower energy requirements. Income gains associated with expansion of the modern sector in developing countries may typically be of the latter kind.

More fundamentally, it may also be argued that the concept of "undernutrition" as only a situation in which body weight is in decline (intake being less than expenditure) is too narrow. One can conjecture that there exist intake-expenditure equilibria which can sustain life but are simply too low, as judged by reasonable normative standards for a particular society. For example, intake and expenditure may match, but neither permit the attainment of certain basic capabilities, including activity levels necessary to participate properly in that society.[27] In this broader sense, the individual is clearly "undernourished" although body weight is not declining. From this perspective, it may be better to focus on certain socially determined norms when judging undernutrition, rather than the concept of some minimum requirement level consistent with survival.

3. Household Calorie Demand Functions for Indonesia

Chernichovsky and Meesook (hereafter C-M) have estimated nutrient demand functions embodying both price and income effects for Indonesia using the 1978 National Socioeconomic Survey (the SUSENAS).[28] The prices used are the implicit unit values from the SUSENAS consumption and expenditure data, while incomes are measured by total expenditures on all goods. A loglinear (constant elasticity) functional form is used by C-M. Price effects are estimated for a variety of nutrients (including calories) with respect to various food prices. In keeping with the main interest of this study, I shall focus on their results for the income elasticity of calorie intake; C-M allow this to vary by income group. Their estimated income elasticity of calorie demand is 0.79 (t-ratio of 22) for the poorest 40% of households, falling to 0.30 (15) for the richest 30%.[29]

I shall follow some aspects of the Chernichovsky and Meesook methodology here, though modifying others. One modification is that I shall not use household-specific unit values as prices; rather I shall average unit values across all households within each of the 39 districts ("Kabupaten" or "Kota") in the data set. This is done in the attempt to correct for a possible bias due to the heterogenous quality of even basic food staples. In particular, the variation in the household specific unit values within one market area may be presumed to reflect quality differences, which one would expect to be income and price correlated, leading to a measurement error bias.[30] Comparisons based on the means of household unit values are likely to be less prone to this problem, though it may not be eliminated. However, it was found that this modification to the C-M methodology made little difference to the results.

A second modification is that I shall be concerned with alternative functional forms for the caloric intake model. For example, the C-M assumption of a constant price elasticity across the sample may be considered unduly restrictive.

Following the discussion of the previous Section, the appropriate dependent variable is aggregate household calorie consumption. The SUSENAS estimates this using fixed caloric values applied to surveyed consumptions of 166 catagories of food and beverge for each household, based on seven day recall.[31]

The first basic model considered for this study was similar to the C-M model in that it allowed the income elasticity to vary (by including a term in the squared value of lny) but fixed the price elasticities. A fairly wide range of household characteristics were included: number of adults (NA), number of children (NC), age of household head (A), schooling of head (S), sex of head (G), and dummy variables for farming households (F), rural households (R) and for season (S_1, S_2, S_3 for February, May and August respectively[32] - the December season being omitted to avoid multicollinearity). In addition, quadratic terms in NA, NC, A and S were included. The food prices used in the model were for the three main foodgrain staples of East Java: rice (by far the most quantitatively important source of calories), corn (of some local importance in the region) and cassava. Unfortunately (though in common with other household income-expenditure surveys) the data set does not include the body-weights of household members. This ommission would probably lead to overestimation of the income elasticity of calorie intake at given body weight (assuming that body-weight and income are positively correlated). The data set only provides a single cross-section on all variables, so it is not possible to test for fixed effects, or to distinguish short-run from long-run caloric intake responses.[33]

The C-M specification gave very significant estimates of the income and rice price coefficients using the 1981 SUSENAS data tapes for East Java, and most of the household characteristics were also significant. The value of R^2 was 0.58. The coefficient on log income was 1.72 (t = 13) and -0.067 (t = 10) on its square value. Thus, as for the C-M study, the income elasticity of calorie demand declines with income. The estimated income elasticities are in close accord with the C-M results. The rice price elasticity is, however, a good deal higher (in absolute value) than C-M obtained, being -.59 (t = 7.3). Neither corn nor cassava prices were found to have significant effects on calorie intake, although this may be due more to their heterogeneity and consequent problems of using unit values (even district means) as prices.[34]

However, this specification was subsequently rejected in favour of the following linear model with quadratic terms in income and prices:

$$k_i = \alpha_o + \alpha_1 y_i + \alpha_2 y_i^2 + \alpha_3 p_i + \alpha_4 p_i^2 + \pi x_i + \epsilon_i \tag{7}$$

where the α's and π are parametric, ϵ_i is a white noise error process, and, as before, the vector of other variables is $x_i = (NA_i, NA_i^2, NC_i, NC_i^2, A_i, A_i^2, S_i, S_i^2, G_i, F_i, R_i, (S_{ji}, j = 1,..,3))$. This functional form clearly dominated the logarithmic model by a number of criteria, including $\bar{R}^2$, the Ramsey RESET test on functional form,[35] and the absolute t-ratios of the main parameters of interest (particularly the income coefficients). By the same criteria this specification also dominated a modified version of the original C-M model, augmented by a quadratic term in log price. A variation on (7) was also estimated allowing an interaction effect between price and income (in the form of an additional regressor y_ip_i), but this did not prove to be significant.

Table 1 gives the coefficients of preferred model (equation 7) and both their ordinary standard errors and White's standard errors adjusted for heteroscedasticity.[36] The Ramsey RESET test on squared fitted values gave t = 2.65; while this is significant (suggesting that some of the non-linearity in the relationship remains unaccounted for by the model), it is far lower than any of the values obtained for the alternative specifications; for example, the logarithmic model gave t=10.0. No tests were made for exogeneity of the income measure (total expenditure), though there is evidence for similar settings suggesting that this is unlikely to be a problem in calorie demand models.[37] The preferred model accounts for 65 percent of the variance in calorie consumption, which is high for a cross-section regression using such a large number of observations.

Comments on the Results

The results in Table 1 contain a number of points of interest:

i) In keeping with other recent studies of calorie demand in low-income countries,[38] the income elasticity is typically fairly low; at mean points, the income elasticity implied by the regression coefficients in Table 1 is 0.146. The preferred functional form thus gives a lower elasticity at mean points than C-M's estimate, though it is unclear why this is so.

ii) However, the concavity is marked. For example, at one half standard deviation below the mean, the income elasticity of calorie intake rises to 0.334.

iii) A striking result is the relatively high value implied for the rice price elasticity of calorie intake. At mean points, this has a value of -1.13, which is a good deal higher (in absolute value) than the C-M estimate, and higher than the log-linear estimate obtained on these data, as discussed earlier. Rice prices may well be picking up an omitted variable. One possibility is that calorie consumption from prepared foods bought outside the home (such as from local street stalls and restaurants) is thought to be underestimated by the SUSENAS (in common with other household surveys). And it may be argued that this is more prevalent in certain dense urban areas where rice prices are also higher.

iv) There is a marked concavity in a number of the non-budgetary household characteristics, notably number of adults, age of head, and schooling of head.[39] Calorie intake is increasing in all three characteristics at mean points, and (as one would expect) this also holds over the span of the data for number of adults. The turning points for age and schooling are within the range of the data, being at 56 years (about one standard deviation above the mean) for age, and 5.3 years (one half a standard deviation above the mean) for schooling. The inverted U shape for age is plausible, though that for schooling is more difficult to interpret; one possibility is that it reflects lower energy requirements of the jobs performed by more highly educated people.

v) Both the farming and rural dummy variables have significantly positive effects on calorie intake. Again these may reflect the greater energy requirements of agricultural work. Note that the omission of these dummy variables would have lead to underestimation of the income effect on caloric intake (since incomes tend to be lower in the rural farming sector).

vi) Although the method of comparing caloric attainments outlined in the previous section is more general, the results of Table 1 can also be used for demographic scaling. In view of the quadratic term in NA, it is easier to construct a scale of "equivalent children" (rather than adults); the number of equivalent children in any household is then given by NC + 1.55NA - 0.0252NA^2. The mean number of equivalent children is 5.997 (made up of 3.39 adults and 1.11 children).

vii) The elasticity of household calorie consumption to the number of equivalent children is 0.716 at mean points, so that calorie consumption per equivalent child decreases as the number of equivalent children in the household increases, ceteris paribus.

4. Simulated Income Effects on Caloric Undernutrition

Following the approach discussed in section 2, the dimension used in measuring undernutrition will be reference calorie consumption, as defined by equation (2). The quantities used to define the reference household are arbitrary - all that we require here is that they are fixed across all households, so that reference calorie consumption is solely a function of the parameters of the household budget constraint or, if deemed relevant, tastes. However, the actual variables used in defining nutritional norms are far from arbitrary.

I shall consider two possible sets of control variables defining the reference household. The first comprises the numbers of adults and children, the age and sex of the household head, and the seasonal dummy variables. I shall refer to this as the <u>compact reference</u>. The second comprises all explanatory variables in the calorie demand model, excluding the budgetary variables (prices and incomes) and including the regression residuals. This is termed the <u>expanded reference</u>, and it may be interpreted as the extreme case in which (following the discussion of section 2) one desires to control for all variation in both tastes and needs when assessing undernutrition.

For the compact reference, the preferred econometric model of calorie demands (equation 7) implies that reference calorie consumption is given by:

$$\begin{aligned} k_i^r &= \alpha_o + \alpha_1 y_i + \alpha_2 y_i^2 + \alpha_3 p_i + \alpha_4 p_i^2 + \pi_1 \bar{x}_1 + \pi_1 x_{2i} + \epsilon_i \\ &= k_i - \pi_1 (x_{1i} - \bar{x}_1) \end{aligned} \tag{8}$$

while for the expanded reference one obtains[40]

$$\begin{aligned} k_i^r &= \alpha_o + \alpha_1 y_i + \alpha_2 y_i^2 + \alpha_3 p_i + \alpha_4 p_i^2 + \pi \bar{x} \\ &= \bar{k} + \alpha_1 (y_i - \bar{y}) + \alpha_2 (y_i^2 - \bar{y}^2) + \alpha_3 (p_i - \bar{p}) + \alpha_4 (p_i^2 - \bar{p}^2) \end{aligned} \tag{9}$$

(Noting that, for the expanded reference, $x_i = \bar{x}$ and $\epsilon_i = \bar{\epsilon} = 0$). Thus, in the latter case, inter-household variation in reference calorie consumption is due solely to differences in the price and income parameters of household budget constraints. It should be emphasised that this is to be viewed as a limiting case; nutritional norms are generally based on a relatively small number of control variables, similar to those used above in defining the compact reference. Nonetheless, in the light of the discussion of the previous section, it is of interest to examine how sensitive the empirical results are to changes in the choice of referencing variables.

The cumulative frequency distributions of both reference calorie consumptions are given in Figure 1. These are based on the distributions of household consumptions per week, though for ease of interpretation I have expressed the horizontal axis as "calories per person per day", evaluated at the mean household size of 4.49 persons.

The slopes of the distribution functions are clearly quite high around reasonable caloric norms in both cases, though more so (for any given norm) for the expanded reference, since fewer household characteristics are then free to vary. For example, the interval elasticity of the distribution function for <u>compact</u> reference consumption is 1.8 between 2,000 and 2,400 calories per day, while for the <u>expanded</u> reference it is very high indeed at 13. Clearly income effects on the extent of undernutrition are going to be considerably greater using the expanded reference.

It should be noted that (by construction) the distribution of intakes based on an expanded reference will have lower variance than for a compact reference. The purpose of the control variables is to eliminate certain sources of intake variability when making interpersonal comparisons of undernutrition; in general, the more control variables are used, the less disperse will be the distribution of intake for the corresponding reference household. As a consequence, the expanded reference will tend to yield lower headcount estimates of undernutrition than the compact reference at low norms, while the two will reverse rank at some higher norm, as in Figure 1. An intuitive way of interpreting this property is to note that, with more control variables, "requirements" (as implicit in the reference intake function) and actual intakes will tend to be more positively correlated, yielding lower estimates of undernutrition, at least relative to low norms. This property underlines the (now widely appreciated) importance of inter-individual requirement variability in quantitative assessments of aggregate undernutrition. The present purpose is not to resolve the long-standing issue of which variables should be used to control for requirement variability, but rather to test how sensitive estimates of the income elasticity of undernutrition are to that choice.

In simulating income effects I shall confine attention to a sub-sample of observations that satisfies a mild consistency condition, namely that the income effect on calorie intake is non-negative. Since a quadratic function has been used to model the non-linearity in the income response, this condition is not automatically imposed on the data, though it is plausible. However, very few data points fail to satisfy these conditions - the income effect is strictly positive for all except two households, giving a reduced sample size of 7200.[41]

For income changes that go in the same direction for all households, the direction of the induced response in the extent of undernutrition is obvious. However, following the discussion in the introduction, one is also interested in the quantitative magnitude of that response. For example, could a small income elasticity of individual nutrient demand (such as that I have found at mean points for East Java) be associated with a large response of the prevalance of caloric deprivation to income changes? Rather than attempt to fix a single minimum caloric requirement for the reference household, I shall consider a range of possible norms, from 60,000 to 70,000 calories per week, equivalent to 1910 to 2230 calories per person per day at the average household size.

Both increases and decreases in all incomes are considered here, since it cannot be presumed that effects on an undernutrition measure will be symmetric. Changes of 10 percent in all incomes are modelled.

Table 2 gives the estimated income effects on the headcount index of caloric undernutrition for both references and the three alternative caloric norms. The estimated elasticities are generally higher in absolute value for an income decline, than an increase, though even for the latter they are at least twice the income elasticity of calorie demand at mean points. As expected, the response is considerably greater for the expanded set of control variables with elasticities as high as 1.7.

Table 3 gives results for the compact reference using the two alternative measures of undernutrition discussed above which are more responsive to the depth of undernutrition than the headcount index, namely the proportionate calorie gap, and the distribution-sensitive measure given by the sum of squared proportionate calorie deficits divided by the sample size. I shall call this FGT(2). The income elasticities are higher than those for the headcount index, except for the lowest norm, and they are consistently higher for FGT(2), though the difference is not large.

The latter result may seem surprising, given that these alternative measures will tend to be less responsive to households crossing the caloric norm in a region where the intake density is found to be fairly high. However, it should also be recalled that the income elasticity of intake is going to be higher for the poorer households. It is this effect, when combined with the higher weight that these measures give to less well nourished persons, that accounts for their higher income elasticities. (Indeed, the distributionally sensitive FGT(2) measure has the additional property that marginal gains in calorie intake have greater impact the lower the initial intake level. Appendix 1 discusses further the theoretical relationship for a general class of undernutrition measures).

It may also be observed from Table 3 that the mean calorie gaps are fairly modest. For example, the increase in calorie intake by energy poor households needed to bring all of them up to an intake of about 2100 calories per person per day represents about eight percent of that amount, or 160 calories per perscn per day, when averaged over all households (whether energy poor or not).[42] Again this reflects the relatively high concentration of households around that norm.

Table 4 presents results of an urban-rural decomposition of the income effects on the headcount index of undernutrition from Table 2. As was noted in the Introduction, urban-rural inequality in East Java tends to be quite pronounced. Thus, it may be surprising that one finds from Table 4 that the urban and rural sectors have similar levels of caloric undernutrition. The (large) sectoral inequalities in average incomes and poverty in East Java are not reflected in the prevalance of undernutrition. The income differences are mitigated by foodgrain price and other relevant differences between the sectors. Also budget shifts tend to have larger proportional effects on undernutrition in the urban sector, where elasticities are as high as three.

5. Conclusions and Directions for Future Research

A recent article on this topic by Wolfe and Behrman posed the question in its title: "Is Income Overrated in Determining Adequate Nutrition?"[43] The authors went on to study nutrient demand functions for Nicaragua and concluded that income elasticities are low, suggesting an affirmative answer to this question.

While the Wolfe-Behrman article is one of the more interesting studies to date on nutrient demand functions (being based on an unusually rich data set), their results should not lead readers to conclude that the prevalance of adequate nutrition or the depth of undernutrition are unlikely to be affected much by income gains or losses incurred by nutritionally deprived households. There are a number of aspects of the measurement of undernutrition with potentially important bearing on the nutritional assessment of income effects, or other displacements in the distribution of intakes. And our primary concern is the income effect on undernutrition, rather than income effects on nutrient intake per se. Two points should be particularly noted:

i) The "adequacy" of any diet is assessed against a nutritional norm, and so one must also look at the distribution of nutrient intakes around that norm in assessing income effects on the prevalance of undernutrition. Most importantly, one must examine the local slope of the nutrient distribution function. And it is not implausible that household nutrient intakes in poor countries will have high density at or around relevant nutrient norms. The headcount index of undernutrition may then be quite responsive to income changes, even if intakes at the norm are not.

ii) It may also be argued that nutritional responses to budget shifts are likely to be larger for the least well nourished persons. This is irrelevant to a simple measure of the prevalance of undernutrition such as the headcount index. But it may matter a good deal to measures of the depth of undernutrition, and other measures which also give higher weight to more undernourished persons in assessing the extent of nutritional deprivation. These measures may be quite unresponsive to changes at or around nutrient norms, but can respond a good deal to the larger income effects one might expect to find amongst the most undernourished persons.

These points are well illustrated by the Indonesian data set for the province of East Java studied in this paper. In keeping with much of the recent literature, income elasticities of calorie intake are fairly low; my preferred model gives an elasticity of about 0.15 at mean points (so that, for example, a 10 percent increase in income would only yield a 1.5 percent gain in energy intake). However, the calorie distribution function is quite steep in a neighbourhood of reasonable caloric requirements. And the income slope of the calorie demand function rises quite sharply as income falls. Thus, the income elasticity of calorie demand at mean points can understate considerably the income elasticity of the prevalance of caloric undernutrition relative to fixed norms. For example, the number of households consuming less than about 1900 calories per person per day is found to respond to an income decrease with an elasticity of about unity using the compact set of reference variables in defining caloric norms. This rises to 1.5 using an expanded set of referencing variables to control for all variation in non-budgetary ("need" and "taste") variables. Measures of caloric deficits and distributionally sensitive measures of undernutrition also tend to yield higher income elasticities. Indeed the effects on these measures are generally even higher than those obtained for the simpler headcount index of the prevalance of undernutrition.

Of course, this is not to say there do not exist alternative policy interventions (such as food price subsidies, leading to higher intakes, or improved health and sanitation services, leading to lower requirements) that may be even more effective at reducing undernutrition for a given social cost than supplementing incomes of the poor. For example, the present study has also found that nutrient intake is quite responsive to the prices of food staples, although it should not be forgotten that producer income effects on undernutrition of food price changes in this setting may be important. The effects on undernutrition of alternative policy interventions beg further research.

With that prospect in mind, I would hope that the main contribution of this investigation is not the precise set of numbers obtained, but rather an applicable methodology for quantifying the effects of budget shifts and other policy interventions on nutritional deprivation. This clearly requires reasonably detailed knowledge about nutrient demand functions. But that is not enough. One must also be concerned about how nutritional effects at the micro level are aggregated in assessing overall impacts on the prevalence and depth of undernutrition. This paper's approach seems to offer a reasonable solution to some of the problems involved. An econometric calorie intake function permits one to control consistently for relevant aspects of intake variability when assessing undernutrition. One need only know the nutrient requirement level of one specific reference person or household in order to judge whether or not each actual household is undernourished, and, if so, by how much. The parameters of the intake model can then be used to simulate the effects of any exogenous shifts in personal or household characteristics on the distribution of a consistent measure of nutrient attainment, and on measures of undernutrition based on that distribution.

This approach does not, however, solve the conceptual problems associated with both identifying which attributes are relevant in controlling for requirement variability, and of assessing the requirement level of the reference household. But the approach does have the flexibility needed to accommodate diverse views, and to test the robustness of key conclusions.

Appendix 1: Effects of Exogenous Shifts in Calorie Intake on a General Class of Undernutrition Measures

This appendix derives a formula for the effect of an exogenous shift in intakes (such as due to budget shifts) on a general class of measures of undernutrition, encompassing alternative measures found in the literature, such as the headcount index and calorie gap. This is used to substantiate various claims made in the main text of the paper.

To simplify notation the calorie intake for the reference household is now denoted $k(y,s)$ ($k_y>0$, $k_s>0$ using subscripts to denote partial derivatives) where y is household income and s is the relevant shift parameter, common to all households. Income has a (continuous) probability density function $f(x)$ and corresponding distribution function $F(x)$. The undernutrition measure for a household with intake k relative to a caloric norm z is denoted $u(k,z)$ ($u_k \leq 0$, $u_z \geq 0$) with $u=0$ for $k \geq z$. The aggregate level of undernutrition is then given by:

$$U(s) = \int_0^{n(s)} u(k(x,s),z)f(x)dx \qquad (10)$$

where $n(s)$ denotes the income cut-off point corresponding to z i.e., $k(n(s),s) = z$ (subsuming z in defining the functions n and U).

Some special cases can be noted. If one sets $u(k,z) = 1$ for all $k < z$ then $U(s)$ collapses to the simple headcount index $F(n(s))$. Alternatively, $u(k,z) = (z-k)/z$ for the proportionate poverty gap measure used in Table 3, while $u(k,z) = ((z-k)/z)^2$ is that Table's FGT(2) measure. Note that both of these measures have the continuity property that $u(z,z) = 0$, and that both are <u>monotonic</u> in the sense that $u_k < 0$ for all $k < z$. FGT(2) also has a continuous first derivative at z (i.e. $u_k(z,z)=0$) and is strictly convex ($u_{kk} > 0$ for $k < z$) and so satisfies Sen's Weak Transfer Axiom.

On differentiating (7) with respct to s one obtains:

$$U^1(s) = n^1(s)u(z,z)f(n) + \int_0^{n(s)} u_k(k,z)k_s(x,s)f(x)dx \tag{11}$$

For the headcount index, this expression reduces to $n^1(s)f(n)$, in which case the effect on undernutrition of a change in s is simply given by the product of the marginal effect at the norm ($n^1(s) = - k_s(n,s)/k_y(n,s)$) and the caloric density at the norm ($f(n)$), as claimed in the text. Alternatively, for all measures with the continuity property that $u(z,z) = 0$, (11) can be interpreted as the integral sum of the products of the marginal effects on intake (k_s) and the undernutrition weights on intake (u_k), where the summation is over the whole intake distribution below the norm. Notice that the contribution of intake shifts at low intake levels to aggregate undernutrition will tend to be higher for monotonic measures, as claimed in the text.

Appendix 2: Summary Data

	Variable	Units	Mean	St.dev.
k	Calorie consumption	Kl/wk	70865	35439
y	Total expenditure	Rp/mn	42823	50158
p	Price of rice	Rp/kilo	216.9	17.6
NA	No. adults (10 yrs+)	no.	3.39	1.73
NC	No. children	no.	1.11	1.12
A	Age of "household head"	yrs	44.6	13.4
S	Schooling of head	yrs	3.27	3.51
G	Sex of head	1 = male	0.83	0.37
F	Farming dummy var.	1 = farm	0.52	0.50
R	Rural dummy var.	1 = rural	0.78	0.42

Notes

1. See, for example, Barbara L. Wolfe and Jere R. Behrman, "Is Income Overrated in Determining Adequate Nutrition?", Economic Development and Cultural Change 31 (April 1983): 525-549; Jere R. Behrman and Barbara L. Wolfe, "More Evidence on Nutrition Demand: Income Seems Overrated and Women's Schooling Underemphasised", Journal of Development Economics 14 (February 1984): 105-128; C.H. Shah, "Food Preference, Poverty, and the Nutrition Gap", Economic Development and Cultural Change 32 (1983): 121-148; John Strauss, "Joint Determination of Food Consumption and Production in Rural Sierra Leone: Estimates of a Household-Firm Model", Journal of Development Economics 14 (January-February, 1984): 77-103; Mark M. Pitt and Mark R. Rosenzweig, "Health and Nutrient Consumption Across and Within Farm Households", The Review of Economics and Statistics 67 (May 1985): 212-225; Jere R. Behrman and Anil B. Deolalikar, "Will Developing Country Nutrition Improve with Income? A Case Study for Rural South India", Journal of Political Economy 95 (1987): 492-507; Thomas Walker and James Ryan, Against the Odds: Village and Household Economies in India's Semi-Arid Tropics, Chapter 9, mimeo, ICRISAT, Hyderabad, India, 1987; Howarth E. Bouis and Lawrence J. Haddad, "Comparing Calorie-Income Elasticities Using Calories Derived from Reported Food Purchases and a Twenty-Four Hour Recall of Food Intakes: An Application using Philippine Data", Discussion Paper 88, Development Economics Research Centre, University of Warwick, 1988. For a recent survey see Jere R. Behrman, "Nutrition and Incomes: Tightly Wedded or Loosely Meshed?" Pew/Cornell Lecture Series on Food and Nutrition Policy, Cornell University, October 1988.

2. This interpretation appears to be due to Shlomo Reutlinger and Marcelo Selowsky, Malnutrition and Poverty. Magnitude and Policy Options, World Bank Staff Occasional Paper No. 22, 1976 (Washington: Johns Hopkins University Press). Also see Shah, Behrman and Wolfe, and Strauss (note 1), and Eugene Silberberg, "Nutrition and the Demand for Tastes", Journal of Political Economy 93 (October 1985): 881-900.

3. For example, see various papers in G.A. Cornia, R. Jolly and F. Stewart (eds), Adjustment with a Human Face (Oxford: Oxford University Press). Also see P. Pinstrup-Anderson, "Macroeconomic Adjustment and Human Nutrition", Food Policy 13 (1988): 37-46. The 1981 World Development Report (Washington: The World Bank) emphasizes income gains to the poor as a means of alleviating undernutrition.

4. See Amartya Sen, Poverty and Famines. An Essay on Entitlement and Deprivation (Oxford: Oxford University Press, 1981). For a survey of recent research on famines see Martin Ravallion, "The Economics of Famine: an Overview of Recent Research", in D.W. Pearce and N.J. Rau (eds) Economic Perspectives: an Annual Survey of Economics (New York: Harwood Academic Publishers, forthcoming).

5. See, for example, Angus Deaton's comments on the Behrman-Deolalikar results for South India, in "Calories, Food and Expenditure: Notes on Behrman and Deolalikar", mimeo, Woodrow Wilson School, Princeton University, 1988.

6. Throughout the paper, I shall merely assert such claims concerning the analytical properties of these measures. Appendix 1 elaborates the theoretical argument for a general class of undernutrition measures, including the headcount index.

7. Again see Appendix 1. The concavity property of intake functions appears plausible on the basis of the extensive evidence on food Engel curves, but the aforementioned intra-food-group substitution possibilities cloud that interpretation. Concavity is best viewed as a testable hypothesis.

8. See the studies listed in note 1. Earlier research on this issue at the World Bank had been concerned with the implications of calorie demand responses for measuring the impact of economic growth on undernutrition, and in assessing the cost-effectiveness of alternative policy interventions; see, in particular, Reutlinger and Selowsky (note 2) and Odin K. Knudsen and Pasquale L. Scandizzo, "The Demand for Calories in Developing Countries", American Journal of Agricultural Economics 64 (1982): 80-86.

9. I refer to the East Java Project in the Research School of Pacific Studies. A volume of papers from the project is in preparation; see H. Dick, J. Fox and J. Mackie (eds) Development of East Java Under the New Order, Mimeo (Canberra: Research School of Pacific Studies, The Australian National University). For background information on poverty in the region, see Martin Ravallion, "Poverty in East Java: Sectoral, Regional and Seasonal Profiles" mimeo (forthcoming in the above volume).

10. This may be compared to an average of 54 percent for Indonesia as a whole. See Dov Chernichovsky and Oey Astra Meesook, "Patterns of Food Consumption and Nutrition in Indonesia. An Analysis of the National Socioeconomic Survey, 1978", World Bank Staff Working Paper No. 670, The World Bank, Washington D.C., 1984.

11. See Jamie A.C. Mackie and D. Zain, "East Java Regional Survey", mimeo, Research School of Pacific Studies, The Australian National University, 1986; and Martin Ravallion, "Poverty in East Java: Sectoral, Regional and Seasonal Profiles", note 7.

12. For example, the degree of income inequality in this data set appears to be very much higher than that found within the South Indian villages studied by Behrman and Deolalikar, who find no significant non-linearity (see their footnotes 3); the coefficient of variation in expenditure for these East Java data is more than twice that reported by Behrman and Deolalikar (compare my Appendix 2 with their Table 1). The CV of income is higher in Wolfe and Behrman's Managua data set (note 1), though they do not report any tests for non-linearity.

13. For empirical evidence in this setting see Martin Ravallion and Dominique van de Walle, "Urban-Rural Cost-of-Living Differentials in a Developing Economy", Journal of Urban Economics, forthcoming.

14. Similarly see Maurice Schiff and Alberto Valdes, "Nutrition: Alternative Definitions and Policy Implications", Economic Development and Cultural Change, forthcoming.

15. See J. E. Foster, J. Greer, and E. Thorbecke, "A Class of Decomposable Poverty Measures", Econometrica 52 (1984): 761-766

16. See, for example, the FAO's Fifth World Food Survey (Rome: Food and Agricultural Organization of the United Nations, 1987), the World Bank's policy paper Poverty and Hunger (Washington: World Bank, 1986), and Shlomo Reutlinger and Harold Alderman, "The Prevalence of Calorie-Deficient Diets in Developing Countries", World Development 8 (1980): 399-411.

17. See Amartya K. Sen, "Poverty: an Ordinal Approach to Measurement", Econometrica 48 (1976): 437-446, and Sen, note 4. For further discussion see Appendix 1.

18. See, for example, the Fifth World Food Survey (note 13).

19. Nanak Kakwani, "On Measuring Undernutrition", Oxford Economic Papers, (1988), forthcoming.

20. See, for example, Wolfe and Behrman; Pitt and Rosenzweig (note 1).

21. See, for example, Energy and Protein Requirements, Report of a Joint FAO/WHO/UNU Expert Consultation (Geneva: World Health Organization, 1985).

22. For an overview of the issues involved see Michael Lipton, "Poverty, Undernutrition and Hunger", World Bank Staff Working Paper No. 597, 1983. My own understanding of these issues has been greatly enhanced by reading Siddiqur Osmani, "Controversies in Nutrition and their Implications for the Economics of Food", Working Paper 16, World Institute for Development Economics Research, Helsinki, 1987.

23. For example, see P.V. Sukhatme, "On Measurement of Undernutrition", Economic and Political Weekly 17 (December 1982), and T.N. Srinivasan, "Malnutrition. Some Measurement and Policy Issues", Journal of Development Economics 8 (1981): 3-19. Also see the joint FAO/WHO/UNU report on requirements (note 18).

24. A sufficient condition for it to remain true that measured undernutrition will decrease with an exogenous increase in caloric intakes is that intakes arem are elastic at all levels to the shift parameter than is the caloric norm.

25. For a survey see Partha Dasgupta and Debraj Ray, "Adapting to Undernutrition. The Clinical Evidence and its Implications", mimeo,

The World Institute for Development Economics Research, Helsinki, 1986, and in Jean P. Dreze and Amartya K. Sen (eds), The Political Economy of Hunger (Oxford: Oxford University Press, forthcoming). Also see Osmani, note 22.

26. Michael Lipton has argued along these lines in correspondence with the author, November 1988.

27. Similarly the joint FAO/WHO/UNU report (note 17) recommends that "energy requirements" should "...allow for the maintenance of economically necessary and socially desirable physical activity" (p.12), as well as good health. For discussion of the idea of "capabilities" as the relevant concept for measuring welfare and assessing deprivation (including undernutrition) see Amartya Sen, Commodities and Capabilities (Amsterdam: North-Holland, 1985). Also see Sen's discussion of calorie requirements in Resources, Values and Development, Chapter 15 (Oxford: Blackwell, 1984). Osmani's paper (note 19) is also well worth reading on this issue.

28. See note 10. Also see Harold C. Alderman and C. Peter Timmer, "Food Policy and Food Demand in Indonesia", Bulletin of Indonesian Economic Studies, 16 (1980): 83-93, and Pitt and Rosenzweig (note 1). There have also been some estimates using aggregate data; see, for example, Odin Knudsen and Pasquale Scandizzo, note 7.

29. Chernichovsky and Meesook (p.43) (note 8); this is somewhat on the high side compared to the other estimates mentioned in footnote 25.

30. See Angus Deaton, "Estimation of Own- and Cross-Elasticities from Household Survey Data" Journal of Econometrics 36 (1987): 7-30. Also see Dominique van de Walle, "On the Use of the SUSENAS in Modeling Consumer Behaviour", Bulletin of Indonesian Economic Studies, 24

(1988): 107-122, where it is suggested that this is unlikely to be a serious problem in using the SUSENAS.

31. Note that, being a consumption based survey, the calorie measure in the SUSENAS is based on recalled food intakes, rather than purchases; on the importance of this distinction see Bouis and Haddad (note 1).

32. The SUSENAS interviews were spread over four quarters and each record is dated.

33. This would require panel data. For an attempt to investigate dynamic effects of income on nutrition using panel data see Alok Bhargava, "Estimating Short and Long Run Elasticities of Foods and Nutrients in Rural South India", mimeo, Department of Economics, University of Pennsylvania, 1988.

34. I also tried using one of the (presumably) more homogeneous sub-categories of corn consumption (notably "shelled corn"), instead of the aggregates. A small negative price elasticity of -.058 was found, but was only mildly significant (t=1.7).

35. See J.B. Ramsey, "Classical Model Selection Through Specification Error Tests", in P. Zarembka (ed.), Frontiers in Econometrics (New York: Academic Press, 1974).

36. See H. White, "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity", Econometrica 48 (1980): 817-838. White's standard errors were computed here using the Shazam package; see K.J. White and N.G. Horsman, "Shazam: The Econometric Computer Program, Version 5.1", Department of Economics, University of British Colombia, 1986.

37. See Behrman's survey in the Pew/Cornell Lecture on Food and Nutrition Policy (note 1).

38. See note 1.

39. The squared term in NC was insignificant and so was dropped.

40. For convenience I use $\bar{y}^2$ to denote the sample mean of y_i^2 (rather than the squared value of $\bar{y}$).

41. The imposition of consistency axioms is common practice in the welfare analysis of tax and pricing reforms. For example, it is widely agreed that, when undertaking empirical welfare analysis using household data, price concavity of the consumer's cost function should either be imposed on the data or on the sample. For further discussion of this practice see Mervyn A. King, "The Empirical Analysis of Tax Reforms", in Truman F. Bewley (ed.) Advances in Econometrics, Volume II (Cambridge: Cambridge University Press, 1988).

42. Though this is best viewed as the minimum caloric cost of eliminating undernutrition, as it would require perfect caloric "means-testing". On the problems of targeting a poverty alleviation budget with imperfect information on recipients' "incomes" see S.M. Ravi Kanbur, "Measurement and Alleviation of Poverty", IMF Staff Papers 34 (1987): 60-85, and Martin Ravallion and Kalvin Chao, "Targeted Policies for Poverty Alleviation Under Imperfect Information: Algorithms and Applications", Journal of Policy Modeling, 11 (1989): 213-224.

43. Wolfe and Behrman (note 1), p.525.

Table 1. Preferred Model of Calorie Demands in East Java

		Coefficient	St. Error (Unadjusted)	St. Error (Hetcov)	Scale
	1	3.68	.344	.389	$x10^5$
Total expenditure	y	2.54	.097	.202	$x10^{-1}$
(Rp/month)	y^2	-1.49	.084	.264	$x10^{-7}$
Price of rice	p	-3.12	.302	.339	$x10^3$
(Rp/kilo)	p^2	6.31	.662	.736	x10
No. of adults	NA	1.31	.047	.084	-
	NA^2	-2.14	.474	.980	$x10^2$
No. children	NC	8.46	.234	.266	$x10^3$
Age of head	A	4.97	1.09	.993	$x10^2$
	A^2	-4.41	1.08	.981	-
Schooling of head	S	3.69	1.89	2.01	$x10^2$
	S^2	-3.45	1.66	1.97	$x10^2$
Sex of head	G	3.31	.754	.665	$x10^3$
Farming dummy var.	F	5.56	.585	.557	$x10^3$
Rural dummy var.	R	3.65	.794	.728	$x10^3$
Seasonal dummies (Feb)	S_1	-1.65	.702	.727	$x10^3$
(May)	S_2	-2.29	.701	.691	$x10^3$
(Aug)	S_3	-2.17	.700	.723	$x10^3$
R^2		.649			
SEE		2.08			$x10^4$
Mean dep. var.		7.12			$x10^4$
F(17, 7184)		782			
n		7202			

Note: the dependent variable is the aggregate value of household calorie consumption in the survey week.

Table 2. Simulated Effects of Income Changes on Caloric Undernutrition

Caloric norm	Compact reference			Expanded reference		
Cal/week reference h'hold*	Original	Incomes** up 10%	down 10%	Original***	Incomes** up 10%	down 10%
60000 (1910)	31.4	29.3 (-.67)	33.5 (.98)	5.05	4.43 (-1.2)	5.83 (1.5)
65000 (2070)	43.3	41.4 (-.44)	45.4 (.49)	22.0	18.9 (-1.4)	25.8 (1.7)
70000 (2230)	55.3	53.3 (-.36)	57.2 (.34)	54.9	49.8 (-.93)	60.4 (1.0)

Note: The table gives the percentages of households in the sample that fail to achieve the caloric norm before and after income changes.
* Daily per person equivalents at average household size are given in parentheses.
** Elasticities are given in parentheses.
*** These are lower than for the compact reference because (by construction) the expanded reference will have a more concentrated distribution (Figure 1).

Table 3. Income Effects on Alternative Measures of Undernutrition

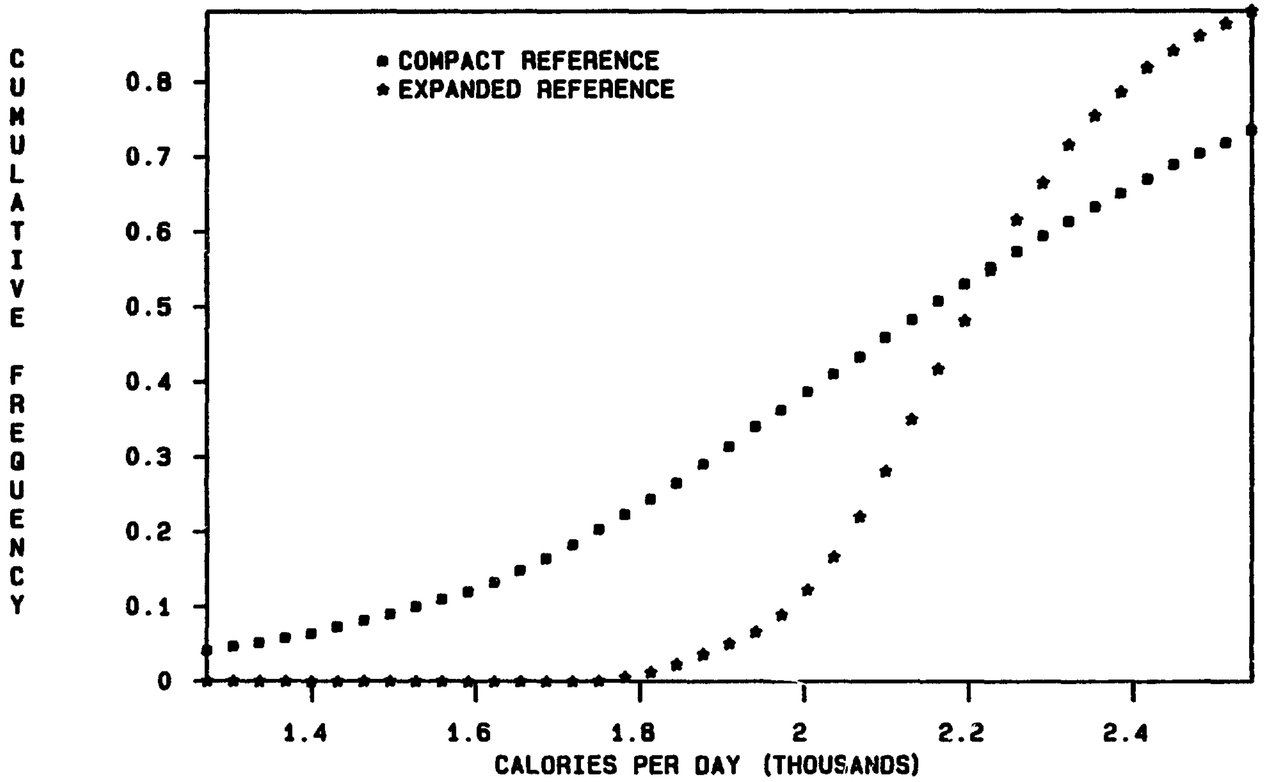
	Proportionate calorie gap (x100)			FGT(2) measure (x100)		
		Incomes			Incomes	
Caloric norm	Original	up 10%	down 10%	Original	up 10%	down 10%
60000	5.31	4.96	5.71	1.64	1.52	1.78
		(-.66)	(.75)		(-.73)	(.85)
65000	7.78	7.31	8.31	2.36	2.20	2.55
		(-.60)	(.68)		(-.68)	(.81)
70000	10.8	10.2	11.4	3.31	3.10	3.56
		(-.56)	(.56)		(-.63)	(.76)

Note: The table gives the values of each measure of undernutrition, before and after income changes. Elasticities are given in parentheses. All estimates are based on compact reference. Results for expanded reference available from author.

Table 4 Urban-Rural Comparison of Income Effects on Undernutrition

		Compact reference			Expanded reference		
			Incomes			Incomes	
Sector	Caloric norm	Original	up 10%	down 10%	Original	up 10%	down 10%
Urban	60000	34.4	31.2 (-.93)	38.1 (1.1)	4.71	3.64 (-2.3)	6.15 (3.1)
	65000	46.2	43.0 (-.69)	49.6 (.74)	22.2	18.5 (-1.7)	25.8 (1.6)
	70000	58.5	55.3 (-.55)	61.5 (.51)	49.5	44.6 (-.99)	55.5 (1.2)
Rural	60000	30.5	28.8 (-.56)	32.2 (.56)	5.15	4.65 (-.97)	5.74 (1.1)
	65000	42.4	40.9 (-.35)	44.3 (.45)	22.0	19.1 (-1.3)	25.8 (1.7)
	70000	54.3	52.7 (-.29)	55.9 (.29)	56.4	51.3 (-.90)	61.8 (.96)

Note: Headcount index of undernutrition before and after income changes with corresponding elasticities in parentheses



COMPACT REFERENCE
EXPANDED REFERENCE
CUMULATIVE FREQUENCY
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1.4
1.6
1.8
2
2.2
2.4
CALORIES PER DAY (THOUSANDS)

FIGURE 1

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